

MEDICAL OFFICERS OF SCHOOLS
ASSOCIATION

School Lighting

BY

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**Medical Officer of Health and School Medical Officer
to the Borough of Wimbledon**

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School Lighting.*

By ELWIN H. T. NASH, D.P.H.,

*Medical Officer of Health and School Medical Officer to the
Borough of Wimbledon.*

In dealing with the question of school lighting I propose first to deal with daylight lighting. Although this is the most important to the pupils, as they spend most of their time working in the daylight, it is the part of the subject which the school medical officer, in this country at any rate, has least to do with in influencing the designs of the schoolrooms. Although it was urged several years ago that the school medical officers should co-operate with the architects in the planning of schools, unfortunately there is a considerable amount of professional jealousy to be overcome, and if it were not for the pioneer work of a few school medical officers and a very limited number of school architects, there would have been very little progress in school architecture.

The first real attempt to deal with the question of school lighting was in 1866, by Cohn, who, by testing with reading types, came to the conclusion that the window area in every schoolroom should be at least one fifth of the floor area. This relation of the window space to floor area has been practically the standard up to the present time. This standard is supported by Blasius and Arnould. The Belgian regulations, however, allow one sixth window space as compared with floor area. In Greece the regulations provide either one fifth or one quarter. In Lausanne it is also one quarter. Truc and Chavernac claim that good lighting can only be obtained with the proportion of 1 : 3 or even 1 : 2 and 1 : 1.5. Some Americans, however, go still further, and demand an equal area of window space to floor area; for instance, in the

* A paper read at a meeting of the School Medical Officers' Association on November 28th, 1913.

Franklyn School, Washington, the window area is actually greater than the floor area. This latter, of course, can only be accomplished by lighting from more than one side.

In 1905 Engelbracht raised the point that one fifth of the floor area was of no use in any room of more than six metres wide, and produced the following formula :

$$f = \frac{F}{5} \times \frac{x^2}{36},$$

where f equals the window glass area in square metres, F equals the given floor area in square metres, and x equals the width of the class-room in metres. This formula will, in the case of most English schools, give a figure of one third instead of one fifth.

In view of this it is important to consider what are the methods of lighting the class-room by means of windows. The four following classes must be considered ; (1) unilateral, (2) bilateral, (3) multi-lateral, and (4) over-head lighting. Where unilateral lighting is provided it is almost always from the left, the regulations of the English Board of Education on this point being that, "The light as far as possible should be admitted from the left side of the scholars. This rule will be found to greatly influence the planning. All other windows in schoolrooms should be regarded as supplementary, or for ventilation. Where the left side is impossible, right light is the next best. Windows full in the eyes of scholars cannot be approved." It is important to consider why, when lateral lighting is used, the left light is always advocated. I think there can be no doubt whatever that this is because the majority of people are right-handed, and it is only the left lateral light that gives entire freedom from annoying shadows on the pen or other writing instrument. Right lighting I consider to be bad, and I consider that there are few new schools which cannot be built so as to provide left lateral lighting. Trelat was one of the first in France to call attention to the importance of left lateral lighting. The value of left lateral lighting is largely dependent on the design and orientation of the school, particularly the design of the class-room, and I wish to refer to this matter later.

Bilateral lighting may be divided into two classes—bilateral lighting proper, in which the two opposing windows are more or less of the same size, and differential bilateral lighting, such as when the lighting from the right-hand side is much smaller in amount than, and supplementary to, the left-hand lighting. This bilateral lighting is very often seen in the older schools,

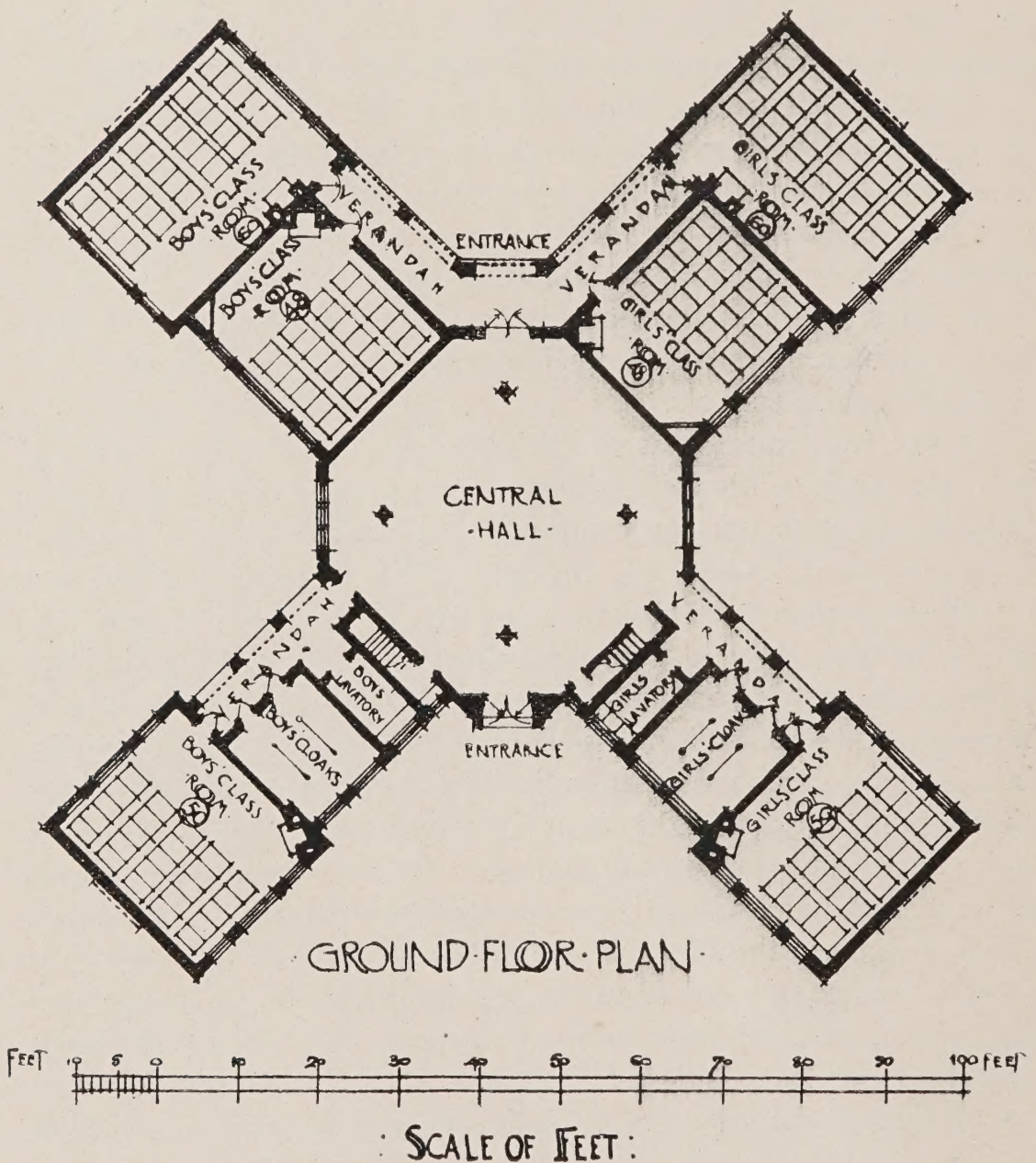
and even to-day in some of the newer American schools, and is due very largely to the large size of the classes, which necessitate more than unilateral left lighting. Its effect is distinctly bad on the greater part of the room, as the children in the middle are confronted with conflicting shadows of almost equal intensity, whereas on the side nearest the source of the right-hand lighting, the children have a preponderating shadow on their work. This is one of the greatest drawbacks to the schools which are known as the Staffordshire type, in which the two window areas on either side are practically equal, although that on the right-hand side does not give quite the same illumination because part of the light is borrowed from a verandah. It is also seen in some of the Derbyshire schools, particularly in the larger school-rooms where the lighting is absolutely equal on both sides, and is worse in this respect than the Staffordshire type. Differential bilateral lighting is also seen in some of the Derbyshire schools.

Trelat, in France, was of the opinion that bilateral lighting was the cause of myopia, whereas Gariel and Javal were of the exactly opposite opinion, claiming that lack of light was a far more frequent cause of myopia than conflicting shadows. Courtious and Dinet claimed that it was possible to get over the difficulty of right-hand lighting by glazing the windows with frosted glass so as to produce a diffused light on that side. Differential bilateral lighting, if properly arranged, can, I believe, be made to give satisfactory lighting, but this will mean that the lighting on the right hand of the pupils will have to be quite small and near to the ceiling. By this means the pupils nearest that window will get practically no light from it, but where it strikes the desk on the left-hand side of the room the preponderance of light from the left hand will be so great as to almost extinguish the shadows, and it has this extremely important property—that by means of the open windows on either side of the class-room really efficient through ventilation can be obtained. This differential lighting can be seen in some of the Derbyshire schools, but the value of its differential qualities has been arrived at by accident rather than by intent, as the greater part of the right-hand side of the class-room is window space, but owing to the presence of a very heavy-tiled verandah outside, the light coming from the lower two thirds of the window is practically a negligible quantity. This is still one of the matters which we have to investigate, but I am convinced that we shall be able to get over the difficulties of differentiation so that we shall be able to evolve an efficient

factor which will give satisfactory lighting with the added boon of through ventilation. One of the matters which has to be taken into account in this differential lighting is the orientation of the building.

Multi-lateral lighting is the attempt to realise, as far as

FIG. I.

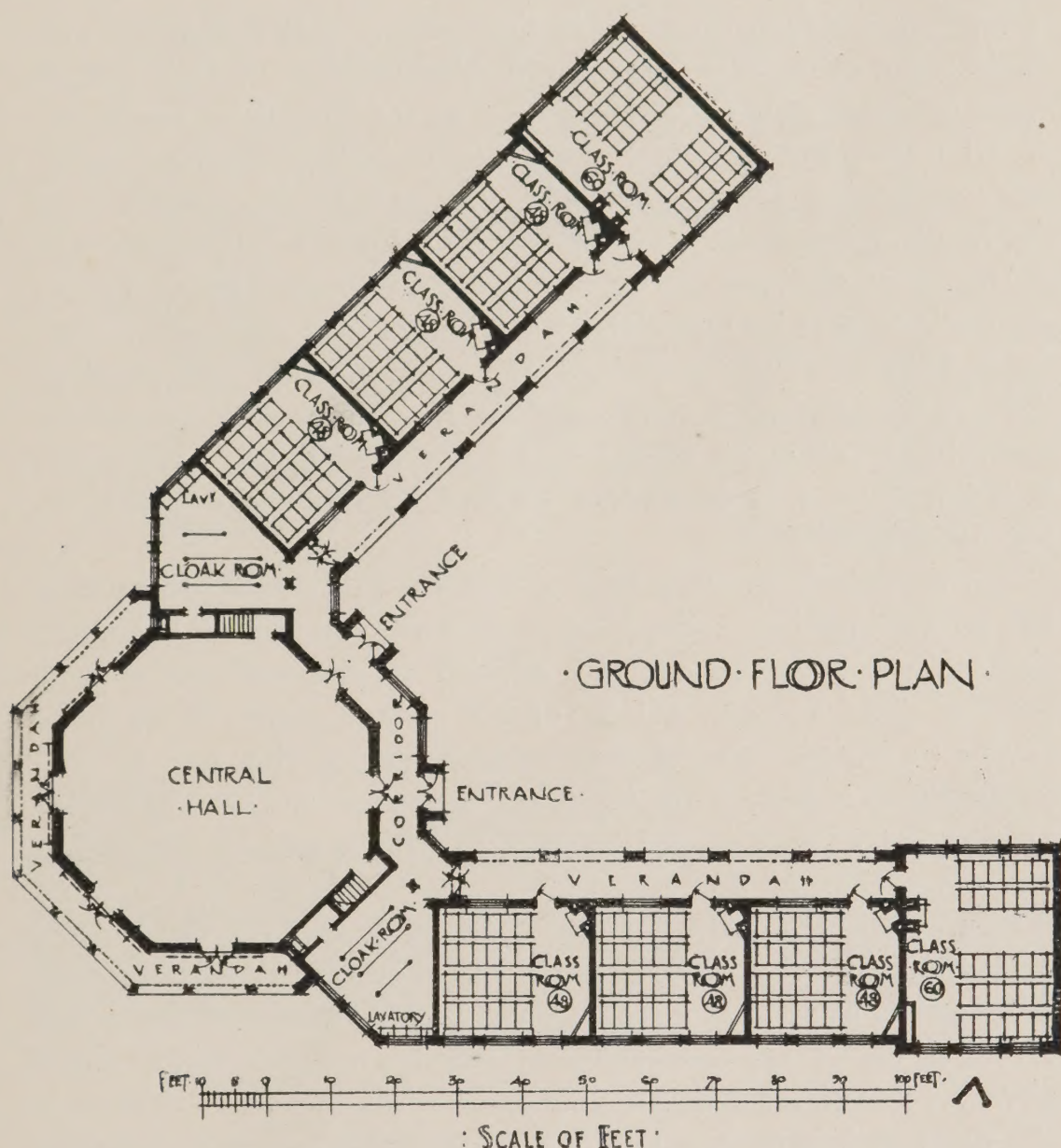


Plan of Derbyshire School, showing bilateral lighting of end class-rooms.

possible, the conditions found in the open air; if this is combined with windows facing the children, it can only have a bad result. Again, light coming from the back can only produce shadows which fall on the children's work, and if the predominant light is from the back, it is very noticeable, as was pointed out by Dr. Kerr, how the children take up all sorts of malpositions in their efforts to dodge their own shadows.

Several of the American authorities regard this rear light, combined with left lateral lighting, as a desirable feature, and a large number of modern American schools are being built on this plan. In addition, this form of lighting is seen in some of the model schools in Upsal and also in some of the new schools

FIG. 2.



Plan of Derbyshire School, showing bilateral lighting of end class-rooms, and differential bilateral of the other six class-rooms.

at Lausanne. Combe, although strongly opposed to bilateral lighting, regards this form of lighting as the best, provided that the windows at the back are large and near to the ceiling.

Overhead lighting gives one of the most even, diffused, and at the same time the best light to work with, provided that it comes somewhat from the front, as is seen in factories where what is known as the saw-toothed roof is in existence. This form of window, unless it faces north, in which case the sun

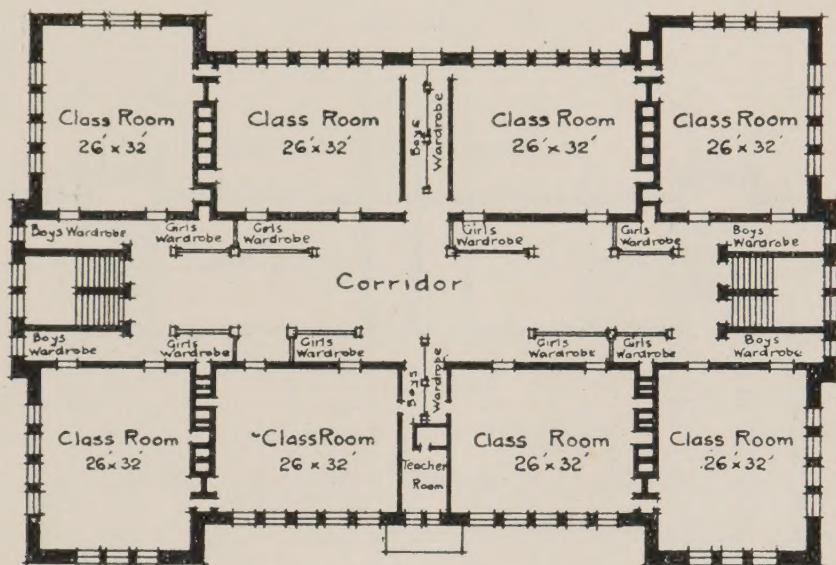
never enters, is apt to be extremely hot in summer, and it is urged against it that it is liable to get obstructed by dirt and snow. Overhead lighting is forbidden in France, but notwithstanding this, Trousseau claims that it is the best light of all and has great advantages, but it can only be employed in single-storeyed buildings or on the top of buildings with more than one storey.

During our investigations in Derbyshire in the summer we made some observations in an old school where, at first sight, it appeared that the conditions were as bad as they could be. Apart from lighting which was chiefly derived from skylights this was so, but we were struck, and so was the architect of the newer Derbyshire schools, Mr. Widdows, by the excellent character of the light, its evenness, and its freedom from shadow, so much so that he has altered a wing of a school which was being built so as to try and get the same uniform and pleasing light as was obtained there, and at the same time to get the sun into the room by means of accessory windows. How this is being done will be shown on the accompanying plans by Mr. Widdows.

On the whole we may take it that for this country at present left lateral lighting is the ideal to be aimed at, and it is important to see how this can be applied to the ordinary school-rooms. The average height of the school-room varies from twelve to fourteen feet, and the importance of this will be seen in the effect it has on the lighting, and further in the effect it has on the cost of the school building. The Board of Education lay down that in the absence of supplementary lighting the measurement from the window wall of a room fourteen feet high should not exceed 24 ft. 8 in. They further add that the proportions of a school-room should vary with the kind and arrangement of the desks, but a long and narrow room should always be avoided and a room approximating to a square is the most satisfactory. This latter statement is entirely opposed to the practice of the majority of the continental countries, and it has been proved that in a school-room of that depth the desks furthest away from the window, under the present design, are very often badly lighted. The amount of light which enters a class-room is dependent to a certain extent on the surrounding buildings. Javal maintained that in every school-place some sky should be visible, and neighbouring buildings should be distant at least twice the height of the school. In 1882 the French Commission of Hygiene laid down this regulation, that : "When the eye is placed at the level of the desk in the worst-

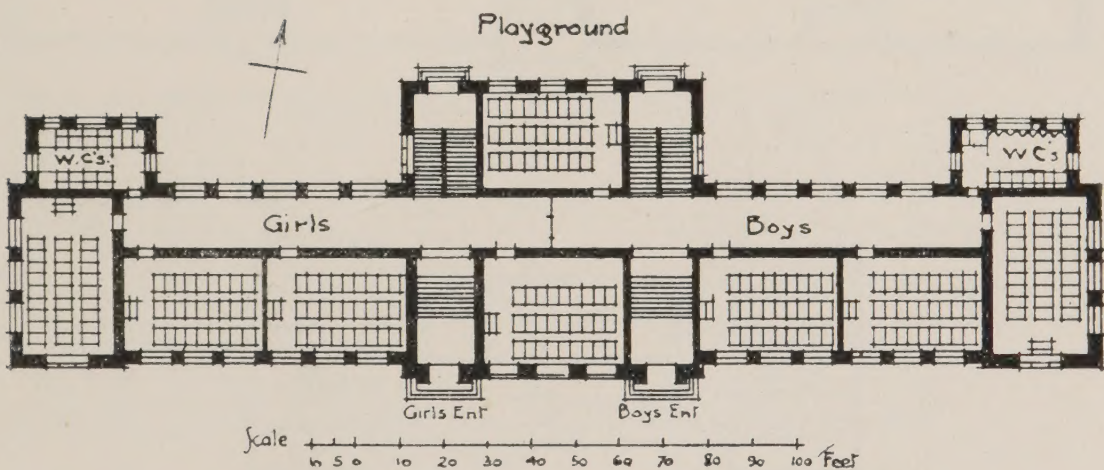
lighted place it should be possible to see the sky for a space extending for 30 cm. at least from the top of the window." In 1884 Forster put forward the suggestion that there should be a minimum angle of four degrees between a line from any desk to the top of the window and another drawn to the top of

FIG. 3.



America. Note supplementary lighting in corner rooms.

FIG. 4.



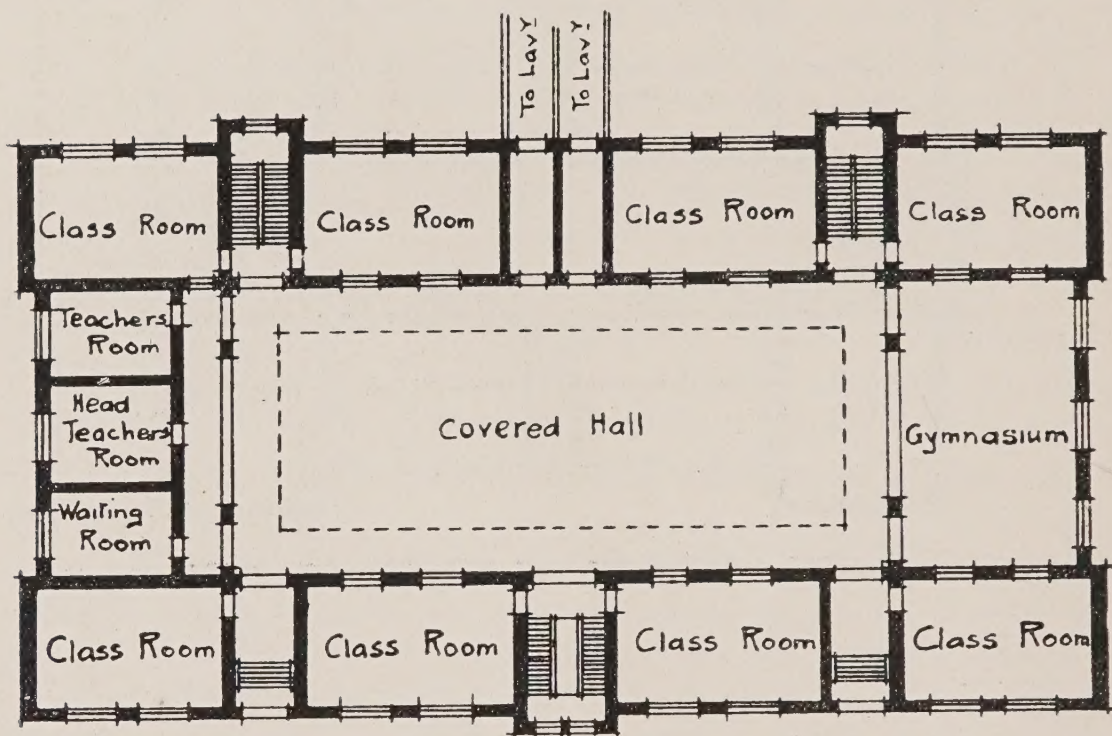
Switzerland. Note shape of class-rooms and only three rows of dual desks.

the nearest building. This he called the opening angle, or Offnungswinkel. The introduction of photometry led Weber to further investigations, and he introduced a gauge for the measurement of what he described as the square angles, or square degrees, of sky area, and laid down as a rule that no place in a class-room was adequately lit which did not show fifty degrees of visible sky area according to his Raumwinkel-messer, and stated that this would be equivalent to an illumination of 10 M.K., or, approximately, one foot candle. Further

development was made by Gilbert, who drew attention to the varying values of the square degrees according to their elevation, and introduced a measurement of reduced square degrees by means of the formula, $\omega \sin a$, where ω represents the actual square degrees, and a the angle of elevation.

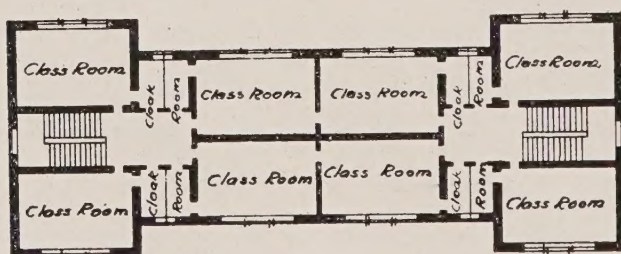
More recently Dr. Kerr has devised an instrument, largely

FIG. 5.



Belgium. Note shape of class-rooms.

FIG. 6.

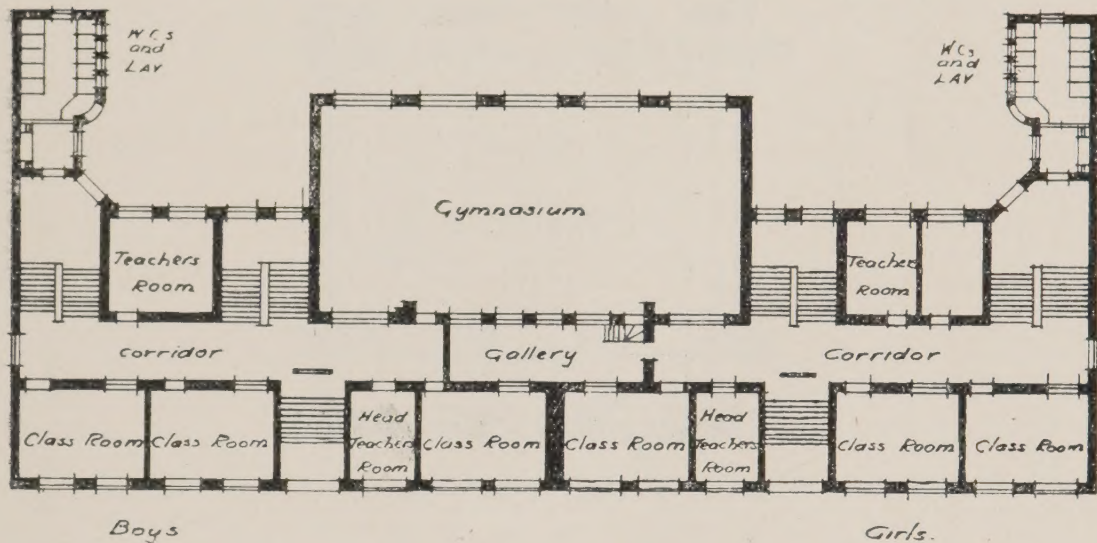


Denmark.

on the lines of the pin-hole camera, which gives a definite diagram in reduced degrees, so that it is possible to put the instrument on any desk and read off at once what is the value of the sky visible from that point. Wingen, before he introduced his photometer, tried to get relative values by means of the actinometric value of exposed photographic paper. This method is of no value, but particularly it is impossible to use where relative measurements are required, as owing to the length of exposure it is impossible to record the varying con-

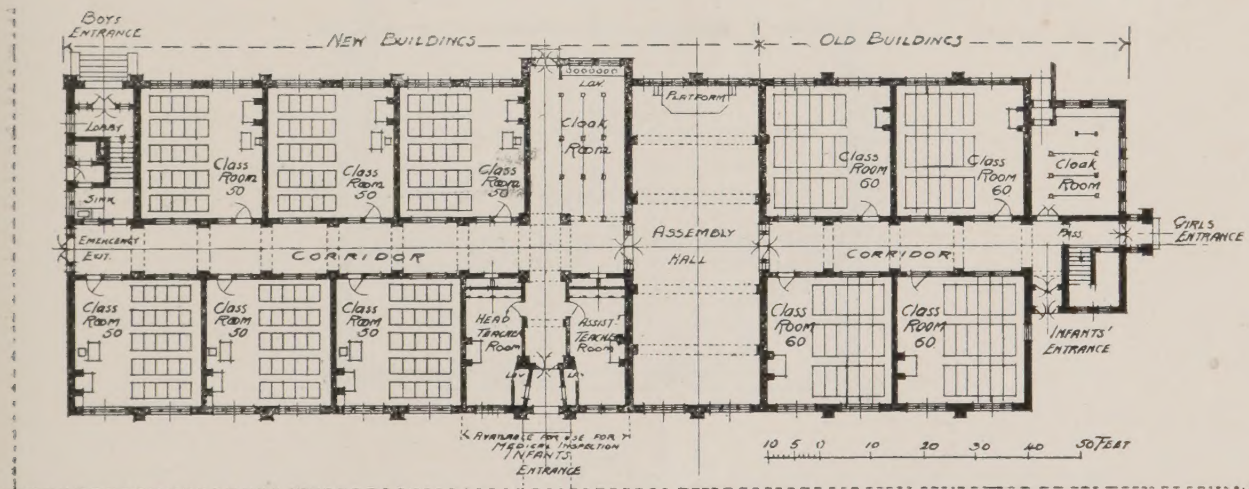
ditions, which may easily vary on a bright day from one to eight thousand foot candles within a few seconds. Unfortunately a considerable number of investigations have been carried out, by Dr. Meredith Young's instruction, in Cheshire in some of the schools, using this method to gauge the luminous intensity of the zenith, with the result that, although much good work

FIG. 7.



Germany.

FIG. 8.

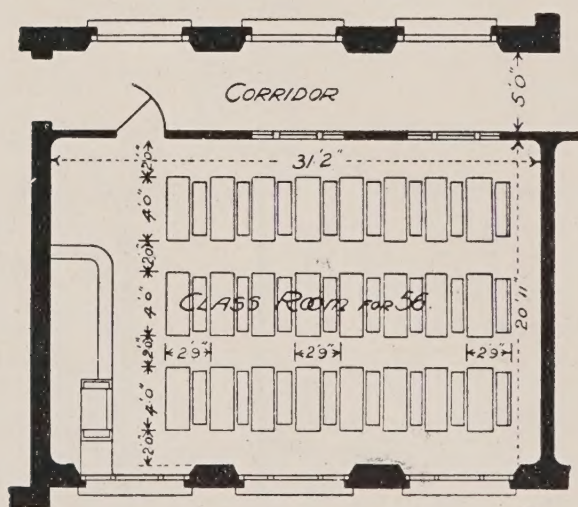
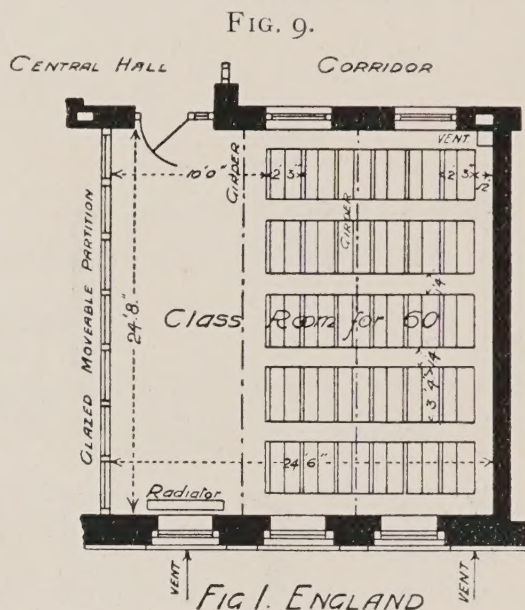


Suggested enlargement of Church School (England). Present rooms with three rows of long desks; suggested rooms with five rows of dual desks. Lighting on corridor side very poor.

has been put into the investigation, the results are of practically no value from the point of view of comparative records.

Reichenbach, of Breslau, expresses doubt as to the practical value of photometry owing to the rapid variations in light, and still pins his faith on the reduced square degree as the best method of measurement of illumination. In addition, a further method of ascertaining the possibilities of lighting of the

furthest desk is by measurement of the angle made with either the floor or the top of the desk and the top of the window, which should be from 25 to 27 degrees with the horizontal. Rutzicka, of Praga, and Pleier, of Carlsbad, tried to ascertain the proportion of light admitted to the school-room



SCALE 10 5 0 10 20 FEET

by taking the photometric readings of the zenith and of the illumination of the desks in the room. Difficulty was found in dealing with the high figures given by the zenith in addition to the rapid variations. Rutzicka laid down the average illumination to be 2000 M.K., and 20 M.K. as the minimum which should be found on any desk, that is, 1 per cent. of the zenith intensity. When we came to investigate these measurements we found that owing to the very high values obtained of the zenith readings, we could get no satisfactory relationship to the

light in the schoolroom. The method which we have adopted is one which I suggested, whereby simultaneous readings by two lumeters are made on the sill of the class-room window and the desk under observation. So far we are finding that we are getting somewhere in the region of 1 per cent. as a minimum of good lighting, which will give a considerably higher value than that laid

FIG. 10.

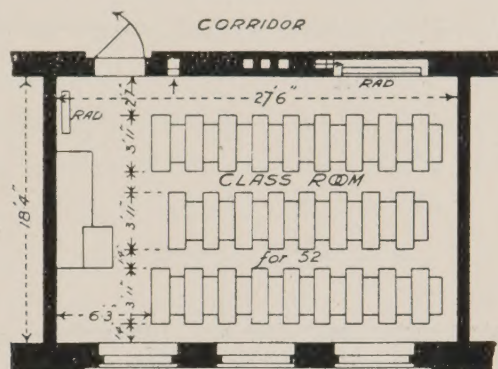


FIG 3 GERMANY.

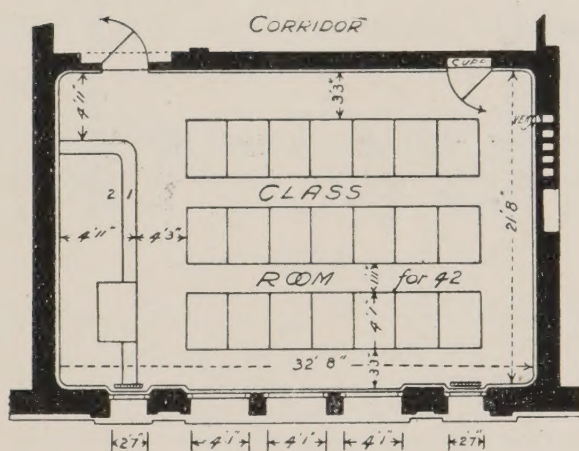


FIG 4 SWITZERLAND

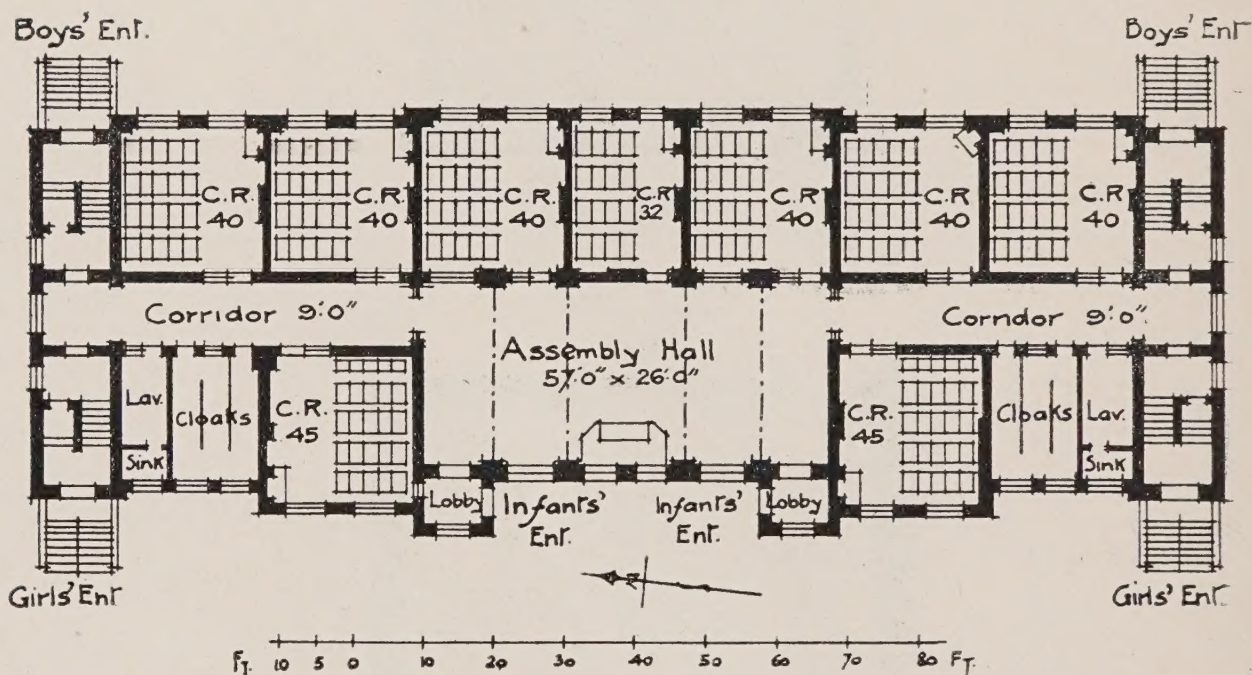
SCALE. 10 5 0 10 20 FEET

down by Rutzicka and Pleier, but it is important that further investigations should be made before definite figures are laid down as to what shall be the minimum sill ratio for any room. Again, the value of the lighting of the desks furthest from the lighting wall will depend very largely on what the nature of the adjacent wall of the class-room is, or whether it has in it any windows opening into the corridor or central hall, which are generally placed there for the purpose of supplementary lighting and occasionally for ventilation. I have maintained for a long time that these supplementary windows are not only of no use for lighting purposes, but actually a nuisance, in that they tend

to create what may be termed a noisy school. These windows round the central hall were introduced first with the idea that it was necessary for the head teacher to be able to see into every class-room. I contend that if the head teacher cannot maintain discipline without such an arrangement the sooner their services are dispensed with the better for the school.

Our investigations have confirmed my opinion in that it was found that the lighting in the rooms with a solid wall opposite the window wall was considerably better at the desks adjoining that side of the room than in those with a borrowed light, the comparative figures being in one set of class-rooms,

FIG. 11.



Pelham School, Wimbledon (Burke Downing). Note borrowed lights in rooms abutting on hall, which diminish the light on the corridor side, the light on the back desk nearest the corridor wall being 5.5 ft. candles in the rooms without borrowed lights as compared with 4 ft. candles in those abutting on the hall.

4 : 5.5 in favour of the solid wall. In these cases the window light is reflected from the wall on to the desks. It is also found in measuring the light in the central hall that these supplementary windows were of no use to the lighting in the class-room. This raises an important point to architects who have to improve church schools particularly, by dividing large rooms with partitions. Except on the rarest occasions these are constructed of wood, the upper part glazed, the idea being that the glass partition helps the lighting. I am convinced that if these partitions were made solid and coloured pale green, the illumination and general conditions in the school-room would be much improved.

The influence of the shape of the room on the lighting and the necessity of careful consideration of the window space may be well seen in some of the figures of a typical London County Council school, where, on the date in question, at a point roughly three quarters of the distance of the width of the room from the window wall there was only $\cdot 4$ to $\cdot 7$ foot candles on the desks.

In America, Warren Briggs has substituted cast-iron mullions for the usual brick, thereby increasing the lateral window surface. Kirby, at the Undercliffe School, Bradford, has also increased his window area by making one large opening in the window wall, extending the whole width of the class-room, and more lately this idea has been carried into effect in one of the large schools in Wales, as illustrated by Sir George Newman in his recent Chadwick Lectures on Open-Air Schools.* Apart from the abolition of wide mullions, the height of the room and the height of the windows is of extreme importance, the most valuable portion of the window being the upper part, and the difference between 12 ft. height in the room and 14 ft. makes all the difference to the light of the further desks, but this means increased cost to the extent of the cube contents of the whole area of the school 1 ft. deep or 2 ft. deep for each storey as the case may be, so that you will easily understand that each foot of height given to increase the light means a substantial addition to the cost of the school building. The Board's regulations demand that the windows shall be taken as near as possible to the ceiling, and in most cases this is done to within about six inches, but in one of the newest schools at Zurich, by special arrangement, the glass surface is taken right up to the ceiling. As it has been found that beyond a certain distance from the window wall the further row of desks is habitually badly lit, the following diagrams will illustrate the influence that this matter has on the design of the class-room proper. Another matter which has a great deal to do with the efficiency of the lighting in schools is, as has been previously pointed out, the surrounding buildings. This is a matter which we are still investigating, and it not only concerns the distance of the buildings, but also the outlook of the class-room, as for instance, a window N., N.E. or N.W., particularly N.E., which is obstructed by buildings, may receive more light by being partially obstructed than it otherwise would owing to the reflection of the sun striking from the south on the facing wall. This matter of obstruction and light values is of extreme

* Brynaerau Council School, Carnarvon.

importance, and we are faced by a large amount of work in determining these matters, also in determining the relative values of each part of a window as to height, and the determi-

FIG. 12A.

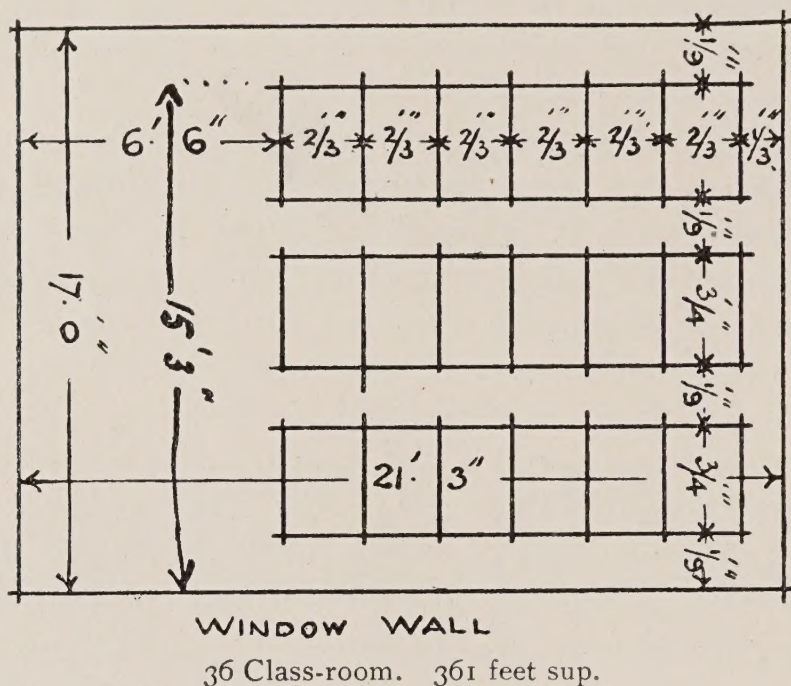
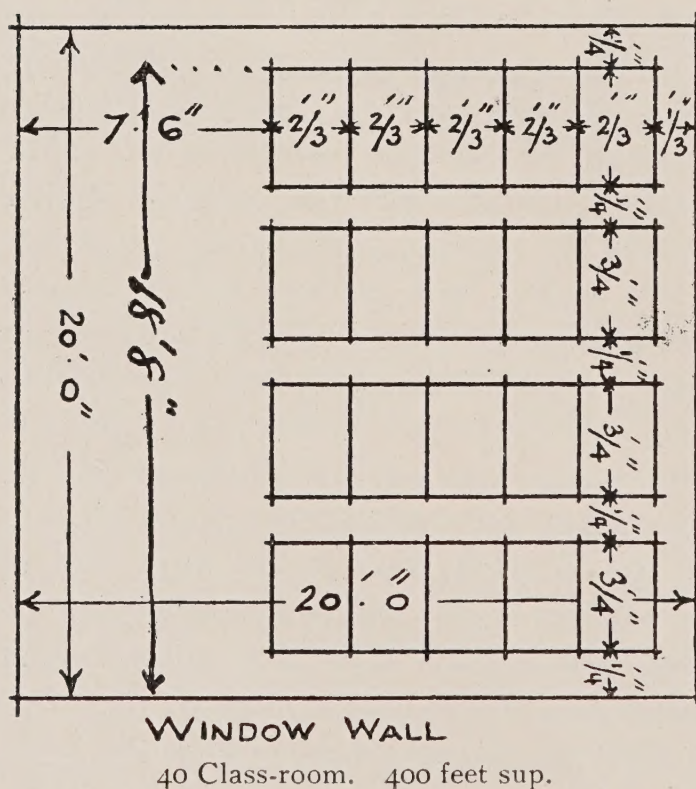


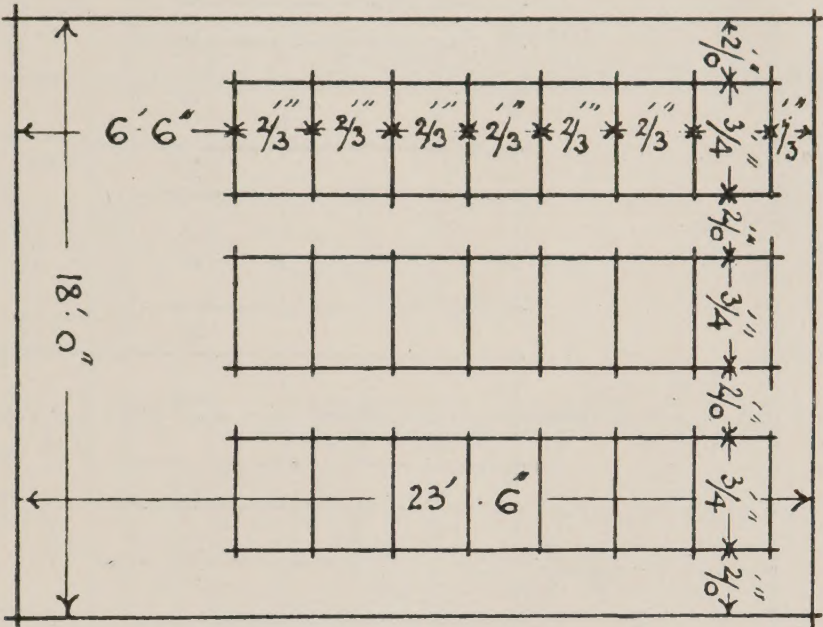
FIG. 12 B.



nation of the value of the lateral light given from any window besides the value of the reflection from the walls in different positions ; these, and many other matters, will take considerable time and expense, and the Committee at the present time are in this position, that, as far as the majority of them are concerned,

the expense of these investigations comes out of their own pockets, and so large are the interests at stake in trying to arrive at what is the best design for any class-room that we feel

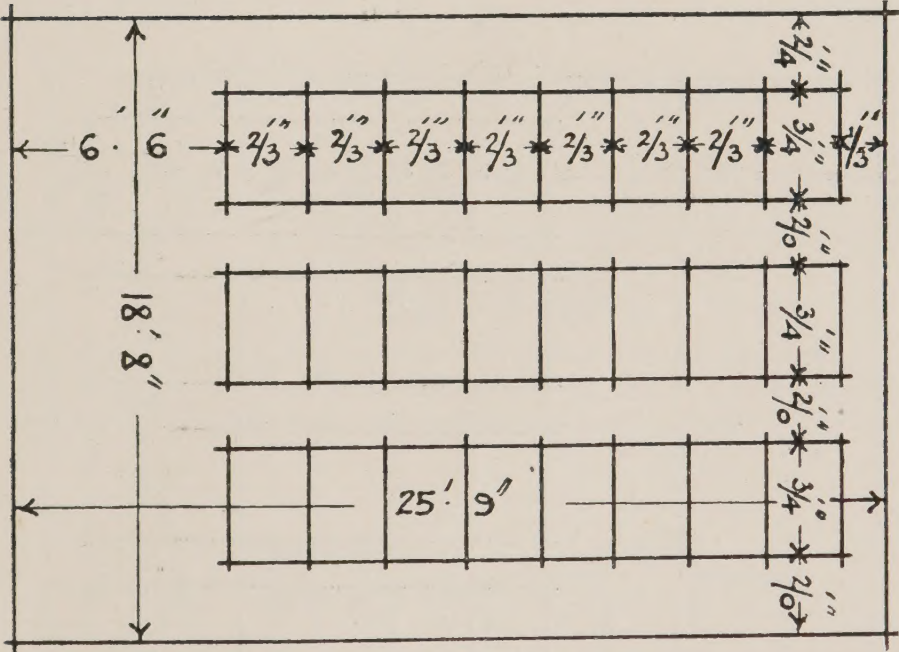
FIG. 13 A.



WINDOW WALL

42 Class-room. 423 feet sup.

FIG. 13 B.



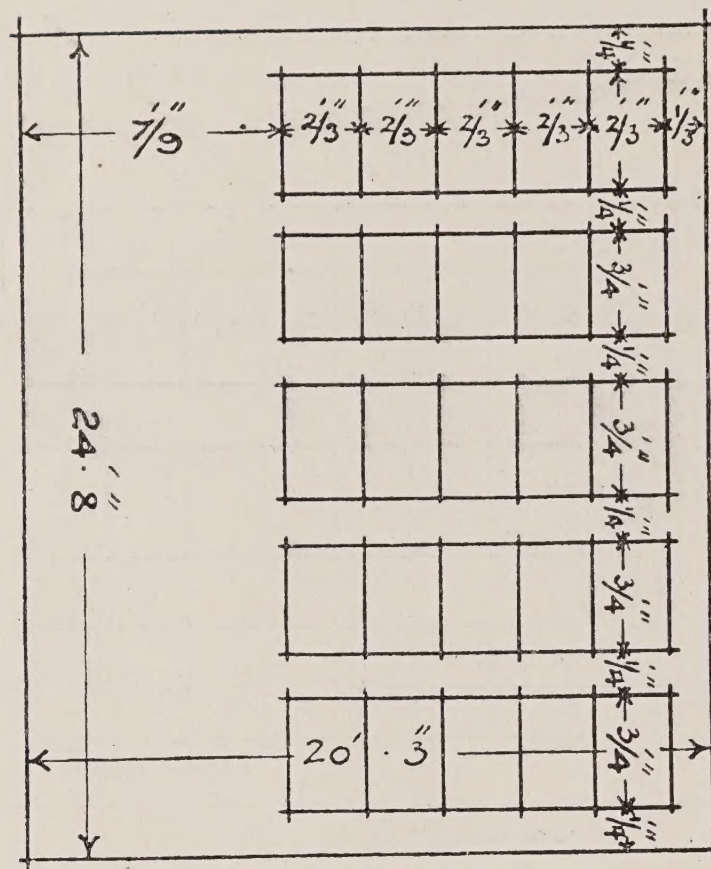
WINDOW WALL

48 Class-room. 481 feet sup.

that the time has come when there should be some substantial help from some source, possibly the Government, or the Government should take over the matter, as, if our findings are correct, it must of necessity influence the whole question of school design in the future. From the architectural side of the

SCHOOL LIGHTING

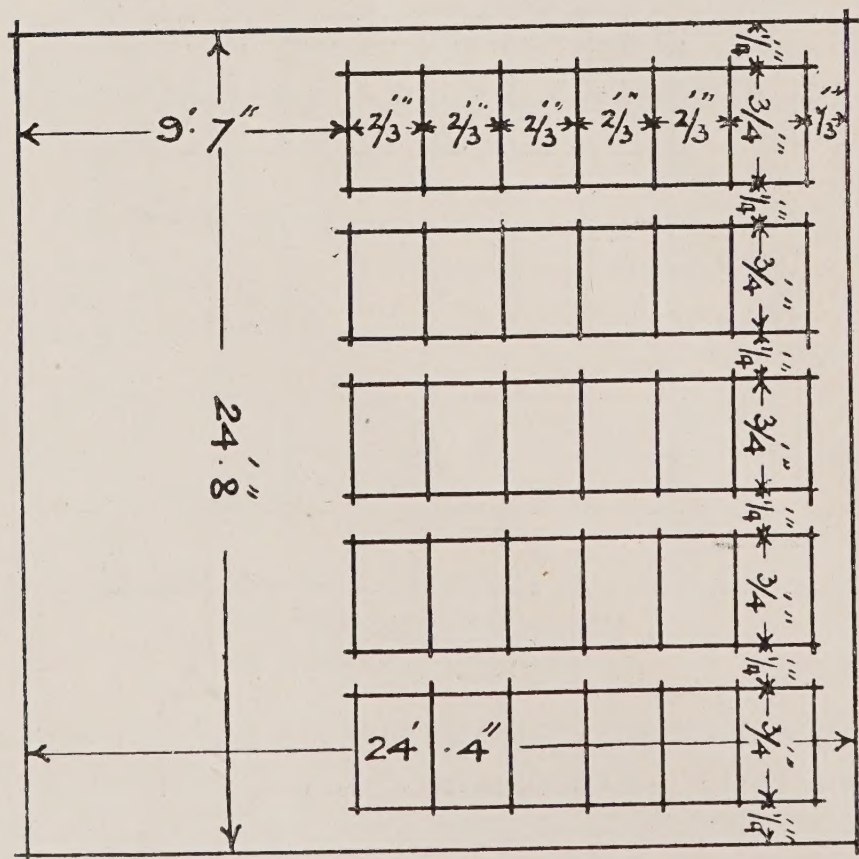
FIG. 14 A.



WINDOW WALL

50 Class-room. 500 feet sup.

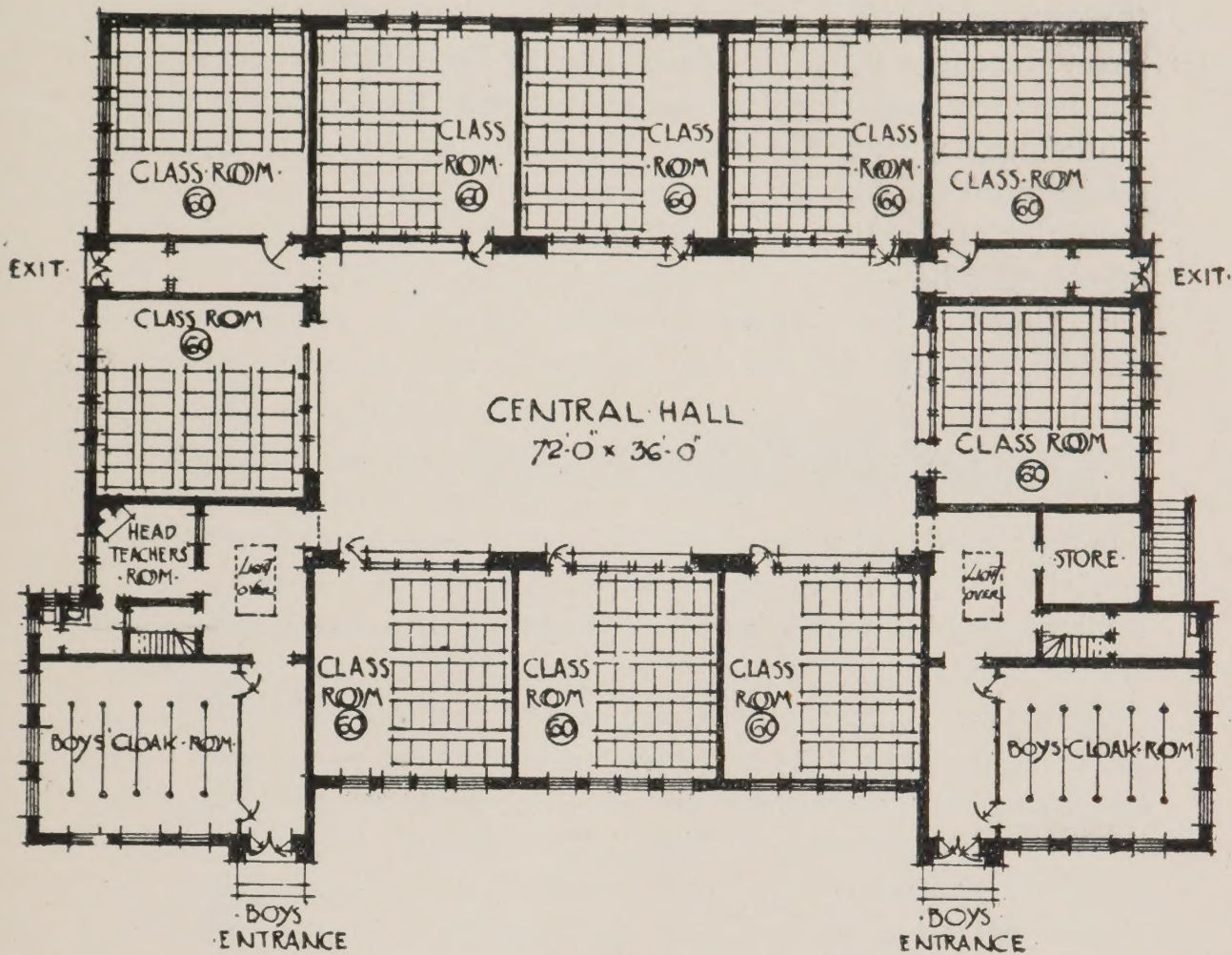
FIG. 14 B.



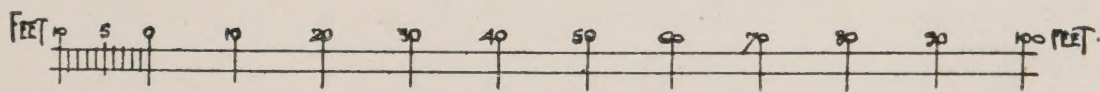
WINDOW WALL

60 Class-room. 600 feet sup.

FIG. 15.



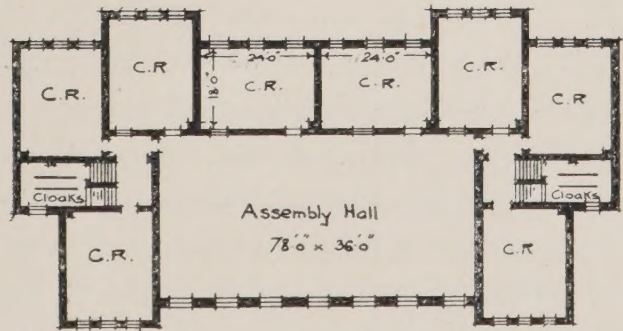
GROUND FLOOR PLAN



:SCALE OF FEET:

Recent plan of West Riding School. Note borrowed lights in all the class-rooms abutting on the central hall. Nothing but borrowed light in the central hall. Practically all the class-rooms ventilate into the central hall.

FIG. 16.



Ben Jonson School, Stepney, 1872. Note left lateral lighting but bad proportions of most of the rooms.

Board of Education, one can expect little help when one sees the extraordinary erections which have been passed comparatively recently by their officers, particularly the type such as has been comparatively recently erected in the West Riding of Yorkshire, where the type of school shows practically no advance on the old Ben Jonson plan of 1872.

Artificial lighting is a subject in which the school medical officer may be able to do more than he can as a rule in the designing of the schools when it comes to re-lighting old schools, but artificial lighting, as far as schools are concerned, has been practically ignored until quite recently, no investigation of any value having been made previous to that made in 1907 by the Boston School Committee, who appointed a committee of oculists and electricians to look into the matter.

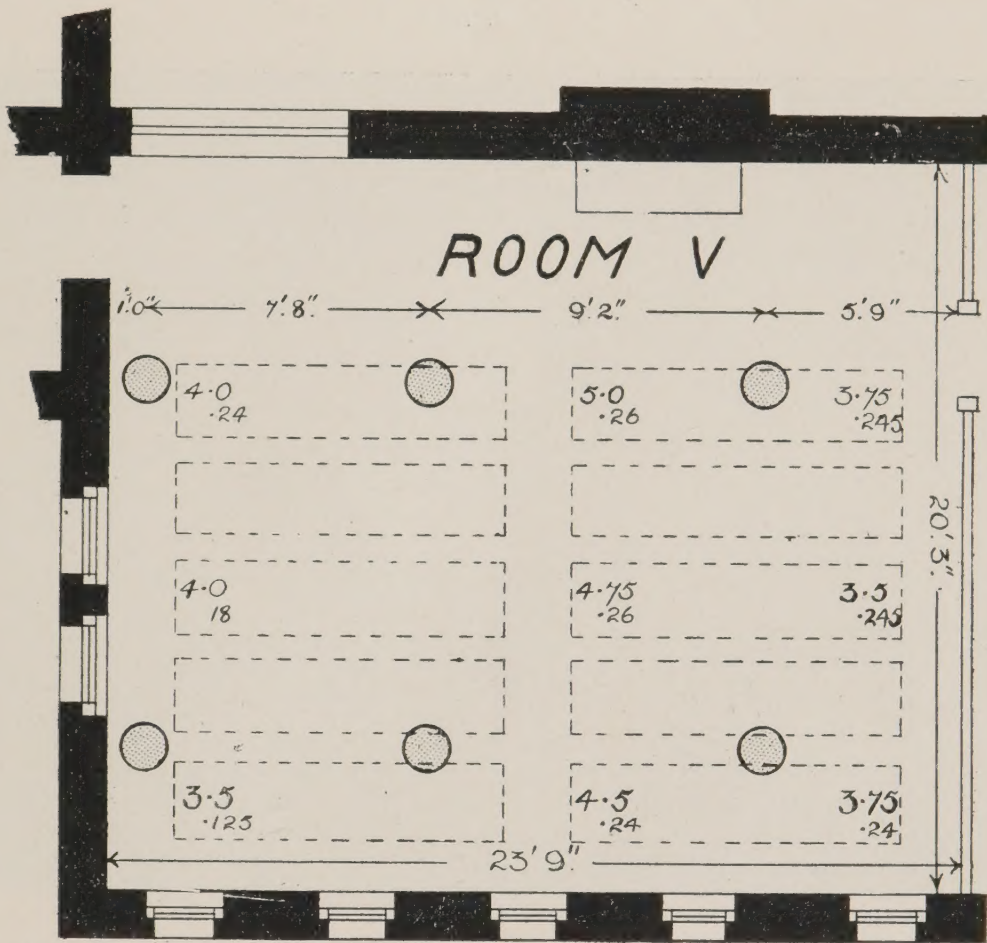
Artificial lighting may be of three kinds—direct, semi-indirect, and indirect. By direct lighting is meant the method which throws the majority of the light on to the surface illuminated. The semi-indirect is that method which throws a percentage of the light upon the ceiling and a percentage from the fitting on to the surface to be illuminated. Indirect lighting is the method whereby all the light is thrown from the fitting used on to the ceiling, from which it is re-directed into the room. Relative values may be expressed in the following figures as percentages of light emitted from the source :

	Lower hemisphere.	Upper hemisphere.	Absorption.
Direct . . .	75 per cent.	20 per cent.	5 per cent.
Semi-indirect . .	20 „	75 „	5 „
Indirect . . .	—	75 „	25 „

For ordinary school work at present indirect lighting may be put out of court on the grounds of expense if the minimum which we have thought right to advocate, viz. two foot-candles, is to be obtained. The light, however, is diffused, very pleasant, and free from shadows, and is also entirely free from glare. The semi-indirect is also free from glare, and does not give the same shadows as are obtained by the direct method. The direct method is, however, the cheapest, but suffers from this defect—that there is difficulty in avoiding glare from the direct source of light. Until quite recently there has been no effort to do anything in the nature of scientifically lighting schools. Although it has been maintained that left lateral lighting is the ideal for daylight lighting, until the report of the Boston Committee there has been no attempt to obtain the same conditions for artificial

light. What generally happens is that the architect, who, as a rule, knows little or nothing about illumination, directs the electrical or gas engineer, as the case may be, to put in so many points of light symmetrically arranged about the room. As a rule he has no idea as to what amount of light he is giving, and a foot-candle, or metre-candle, conveys little to his intelligence. As far as electric light is concerned, the illumi-

FIG. 17.



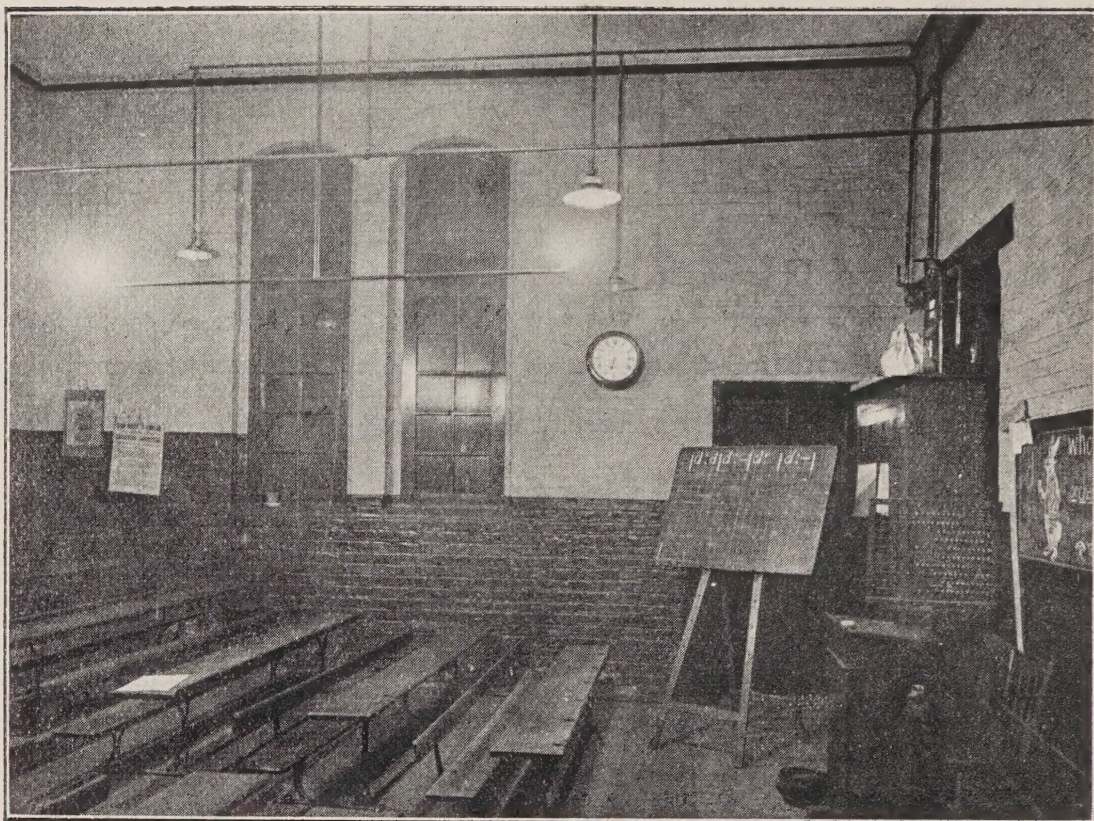
HEIGHT OF LIGHTS FROM FLOOR 9 ft.

Plan of lights in re-lighting an old church school. The larger figures show the new lighting in foot-candles, and the smaller figures the old. The present lighting is by 6 Bray's 1912 inverted burners consuming 4 ft. an hour at $\frac{3}{10}$ pressure. The candle-power is approximately 90 at an angle of 45° . Each lamp is fitted with a 12-in. enamelled iron reflector and "Nico" bulb of clear glass.

nating engineers have, in many instances, worked out the polar curves for lamps, and can prescribe an illumination in the same way that a doctor can medicine, with this pull over the doctor—that they know exactly what the result will be, whereas, in the doctor's case, this may be problematical. The gas engineers so far have not worked out the values for their lamps, and these, to a certain extent, will vary with the quality of the gas used. It is possible, however, to light a room to any given

standard, and I have recently had the opportunity of re-lighting some class-rooms in an old school according to the recommendations of the Joint Committee, with this difference, that whereas we laid down that there should be a minimum of two foot-candles on any desk, taking into consideration the fact that this school was situated in the poorest neighbourhood in my district, where a considerable number of underfed children attended, and where there were a large number of visual

FIG. 18



Class-room lit by four batswing burners, burning 40 cub. ft. per hour. Owing to the ceiling being lit the vault of the room looks comparatively well lit. Compare the light on the floor and details in the right-hand corner with Fig. 19. Maximum light 7 foot-candles. The best comparison of the light on the desks is made by covering the upper part of this and the next diagram as low down as the top of the clock.

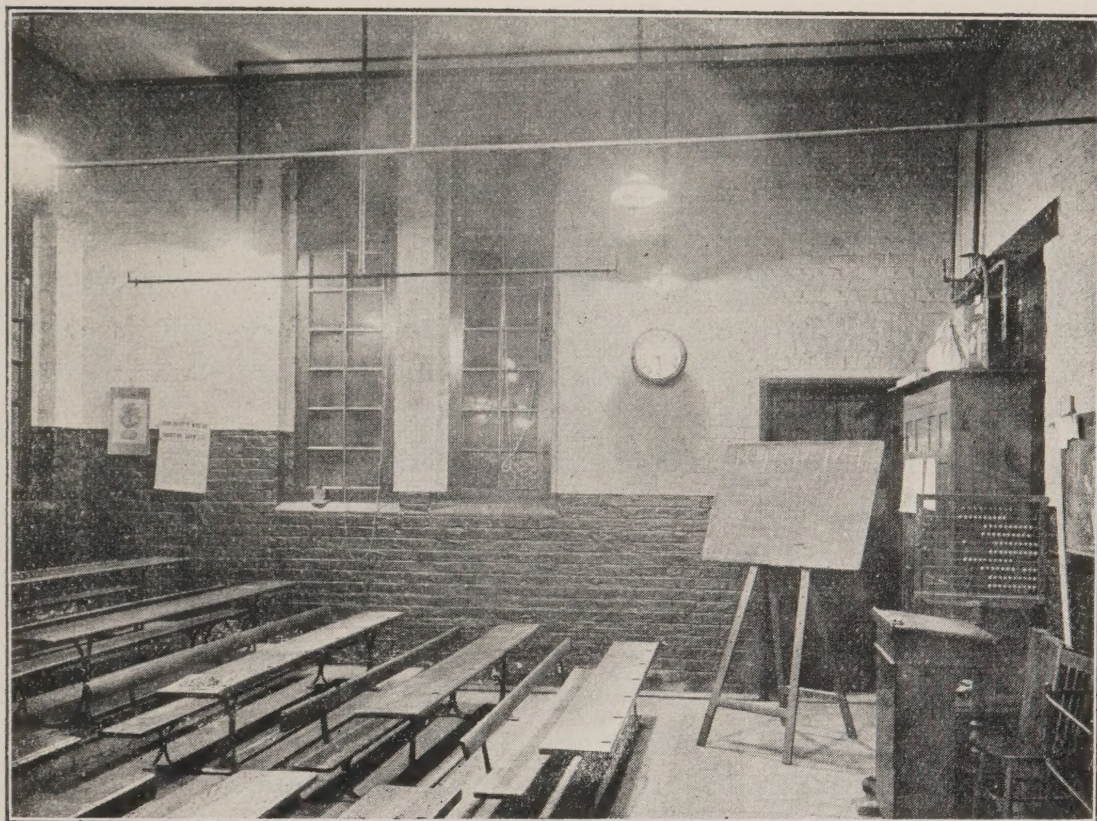
defects, I specified a minimum of 3.5 foot-candles. This, I believe, is one of the first instances in the kingdom of gas-lighting in any school according to a definite scientific formula, and the results are striking, in that by replacing the old burners which were in existence I am able to get eight times the light at roughly the same cost; in other words, I am getting a light equal to practically 3.5 to 4 foot-candles all over the room at a cost, with gas, at 2s. 5d. per thousand cubic feet, of between $\frac{3}{4}$ d. and 1d. per hour, whereas, to obtain the same light by means of electricity would cost approxi-

mately 3*d.* per hour. It is important, in any gas installation, to see that it is governed on the main.

Several investigations and measurements have been made to show the lighting of several of our schools, including some of our big public schools and some of our elementary schools, from which it will be seen that the best lighting is obtained on the whole by some of our gas-lit public elementary schools.

Most of you, I suppose, will have seen in the last number of

FIG. 19.



The same class-room lit with six Bray's 1912 inverted burners, consuming 4 cub. ft. per hour at $\frac{3.0}{10}$ pressure. Note the light on the desks and floor and details in right-hand corner. Cost rather over $\frac{3}{4}$ *d.* per hour. Equivalent light by electricity estimated at 3*d.* per hour. Maximum light 5 foot-candles; minimum, 3.5 foot-candles.

SCHOOL HYGIENE the Interim Report of the Joint Committee on School Lighting, wherein, after much investigation extending over a year and a half, we came to the conclusion that the minimum illumination measured at any desk where the light is required should not fall below two foot-candles. In addition, careful experiments were made with regard to blackboard lighting and the use of coloured chalks, and it was found necessary to advocate that whereas the minimum allowance suggested for reading purposes might be enough in a small class-room where white chalk is mainly used, and no students are further than

twenty feet from the blackboard, a higher value would generally be necessary in larger rooms and on boards where it is customary to use coloured chalk. The Committee came to the conclusion that an illumination on the blackboard of about 60 per cent. in excess of that prevailing in the rest of the room is desirable. This can best be met by local lighting with properly screened lamps. At the meeting of the Society of Illuminating Engineers, where this matter was discussed, I pointed out the difficulty of seeing certain colours even at very short distances. This has been brought home to me by watching children being taught to read when the letters were printed on the blackboard in different colours, generally reds and blues, and very often the first letter of a word being printed in blue and the rest in red, and one instance particularly brought the subject to my notice, as the teacher had executed what was a most paintaking piece of work in this fashion, with the result that practically two thirds of the class could not see the initial letter. The colours which give chief trouble are certain reds, blues, purples, and browns, and this is more marked in what are known as dustless chalks than in the commoner type.

One of the chief things to be avoided is glare, not only from the lights, but also from the blackboard. That from the blackboard is a matter which can easily be got over by tilting it so that the reflected rays do not come near the children, and by seeing that the board is kept a dead black, but this is not so serious as the question of glare from the source of light itself, and it is extremely important that no incandescent surface should be visible from any point of the class-room. The committee have laid down that no light, unless completely screened by a shade impervious to light, should appear within the solid angle subtended by the blackboard and two feet above it. As a result of further experience I want to have this matter re-discussed, as I am of the opinion that this angle is too small. This question of glare raises an important point with regard to the height of the lights from the floor, and it will be seen that this incidentally has a direct bearing on the cost, as the amount of light varies inversely as the square of the distance, so that if the lights are placed higher up it means that a much higher value must be given in order to get the requisite two foot-candles. This raises another point in that the artificial light should be as free as possible from inconvenient shadows. This, of course, can best be obtained by indirect and semi-indirect lighting, but it is difficult to obtain with direct lighting unless there are a large number of units, or fewer high-power units, placed at a greater

distance from the desks in order to minimise, as far as possible, shadows of wide angle. One wonders what kind of shadows must have been produced in some of the French schools when one of the French authors lays it down as a necessary provision, when speaking of gas, "That the lights shall not be near enough to heat the children's heads."

The variations in the lighting, with units of different intensities and varying characters and heights from the floor, will be seen in the photographs of different class-rooms shown on the screen. Here, as is the case with daylight, it is extremely important that the walls should be tinted to a proper colour in order to use their reflective power to the maximum, and windows and glazed partitions are practically of no value from this point of view.

I am indebted to Mr. Kirby, late of Bradford, Mr. W. H. Webb, Mr. G. H. Widdowes, the proprietors of the *Builder*, and the Committee of the Royal Sanitary Institute, for the use of the illustrations of the various schools and schoolrooms.

Medical Officers of Schools Association.

Meeting held at 11, Chandos Street, on November 28th, 1913.

Discussion on Dr. Nash's Paper.

Dr. KERR: The Society is to be congratulated on the extremely full paper on every aspect of school lighting which Dr. Nash has given us. As regards the conditions of daylight for the ordinary class-room we should only recognise left lighting, at least where the majority are right-handed. With bilateral lighting over about one third of the rooms there are difficulties for writing in the shadows about the pen-point. Lastly, lighting from behind must always be condemned, not because the children are in their own shadows, but because the teacher is seriously affected. Facing windows the eye becomes adapted so that children's faces are not well seen, but, even apart from that, for the nervous or debilitated teacher, as so many are, there is strain and headache often in the afternoon and later neurasthenic breakdown. Top lighting for ordinary school-room subjects is good if it can be used, but there are conditions where top lighting is troublesome; for instance, you cannot examine teeth or ears satisfactorily without a head mirror, so that ultimately we come back to left-hand lighting. The ten square foot space in class-rooms is for the small classes now wanted quite good for lighting, but there will be difficulties in ventilation, which is even more important than the lighting.

Dr. FAIRFIELD asked as to the advisability of white or very light-coloured walls in school-rooms. She found in practice that in testing vision in a white-walled room the scholars could rarely read more than $\frac{6}{9}$, whereas they got $\frac{6}{6}$ in a room with darker walls.

Mr. BISHOP HARMAN said he wished to add his voice to the

recommendation that window lighting should be unilateral only, and never bilateral or multilateral. The contention of the advocates of the multilateral plan that they secured a near approach to open-air illumination was fallacious. No number of holes in the sides of a room could make the enclosed space like the open. Further, it was doubtful if the aim of "open-air lighting" was wise, for that was too unstable; it differed from hour to hour, and the desks of the children would need to be changed according to the direction of the sun or of the most luminous cloud patch! Since their work must be done in rooms it was better to get a simple principle established which met the greatest number of difficulties, and that principle was left unilateral lighting. They should press that upon the architects without qualification or exception. It was of the greatest importance to insist upon the necessity that every desk should be so placed that clear sky was visible from it. The difficulty was great in towns, and chiefly by reason of the excessive height of modern buildings. Any influence they could exert to check this tendency to build out the sky should be exerted to the utmost. In the matter of artificial lighting the reader of the paper had given scant attention to pioneer work done under the direction of the London County Council. Neither the Boston Committee nor Dr. Nash were first in the field. In the report of the Medical Officer for Education of March, 1907, would be found the record of an investigation that anticipated in all essentials the work that Dr. Nash had quoted. Even the idea of providing left-hand sources of light that Dr. Nash had adopted in Wimbledon would be found fully worked out in that report. To judge by the pictures shown by Dr. Nash it appeared he had adopted inverted gas-burners in his schools. This form of burner violated one of the canons of elementary day-school requirements—that equipment should be within the power of adjustment of the school-keeper. The inverted burner required regular and expert treatment. The upright burner did not; it was stable and easy to keep up, and it could be done by any school-keeper. The one defect of the upright burner—the shadow cast by the brass-work—could be readily removed by the use of a proper reflector. (He hoped it would not go out that the reflectors figured by Dr. Nash were the patterns used in London schools, for they were not.) In any fitting proposed for day schools it was necessary to bear in mind that artificial light for such schools was for occasional use only. Complexity meant uncertainty when the usage was occasional only. Their schemes must, therefore, provide for

good but simple arrangements. On the score of simplicity the electric glow-lamp had no competitor.

Mr. J. S. DOW said that he wished to express regret on behalf of Mr. L. Gaster, the Hon. Secretary of the Illuminating Engineering Society, at being unable to be present. On the Committee of the Society on school lighting they had derived great help from the co-operation of Dr. Kerr and Dr. Nash, who, in his paper, had referred to several matters the Committee were now considering. One point—the question of unilateral or bilateral lighting—had also a bearing on artificial light. It appeared that considerable assistance to the illumination was received from light inner walls with a good reflecting power. Reflection from surroundings was one of the best means of avoiding objectionable shadows, and he would urge that dark materials absorbing much light should be avoided. Mr. Dow also referred to the desirability of avoiding very glossy paper for school-books. In conclusion, he mentioned that daylight illumination would be considered in a paper before the Illuminating Engineering Society on December 16th, and expressed the hope that some member of the Association would be present.

Dr. A. E. WILLIAMS mentioned a few facts elicited in some investigations in London schools. First, that the value of borrowed light was, indeed, as said by Dr. Nash, very small, and in one case where he was able to measure it, it was less than 2 per cent. of all the light even where measured in the dark nearest the glass screen. He also found the great need of care with coloured letters, and particularly that written on the fixed wall blackboards. These blackboards were, he found, much more seriously deficient in light than the movable ones, the latter being almost always judiciously placed by the teachers; in fact, it was very seldom that the light was improved by altering the position. He also noted the great difference between different schools, and the difficulty of getting over the great variations of daylight from time to time.

Dr. SHRUBSALL pointed out that it was necessary to take all points into consideration when deciding on the design of a class-room. Long rooms had some advantages for lighting on the desks, but from the back desks it was a strain to see the blackboard, and sometimes to hear the teacher's voice, which in turn suffered from strain. Also if the room is long it is more difficult to avoid an artificial light falling within the angle of vision of those pupils in the back row. A long room is also often harder to heat or to ventilate. The square room represents a compromise to most requirements. A point of great import-

ance is to see the windows are clean, and to keep them clean it is almost necessary to ensure that there is no hot coil beneath the windows, or the ascending stream of hot air will lead to deposit of dirt on the windows.

In replying to the discussion, Dr. NASH said he was quite aware of the excellent work done by Mr. Harman in his report to Dr. Kerr on school lighting, particularly with regard to his investigations with respect to the 90 degrees shade, which he understood was refused by the London County Council on the question of cost. With respect to inverted burners as compared with vertical ones, Mr. Bishop Harman's objection was mainly on the grounds that there was evidence of offensive products of combustion, as demonstrated by greater corrosion on the fittings of the inverted burner as compared with the upright. These results are due in nearly every case to improper regulating, and practically all the difficulties in connection with incandescent mantle lighting can be got over by the installation of a governor on the service pipe, which is a comparatively inexpensive matter and does away with the variations in pressure. In addition it must be borne in mind that, for the same consumption, the inverted burner gives, on the average, 33 per cent. more light; and also the life of the mantle is longer than with the upright variety. With regard to the question of the position of the lights, Mr. Bishop Harman will notice that our lights are placed nearer to the left-hand wall than he advocated, and are also higher from the desk.

In reply to Dr. Shrubsall, he would point out that the difficulties he mentions with regard to long rooms in Continental schools apply to classes of sixty or more, and that as far as this country is concerned the days of large classes are over, so that that difficulty will not arise. With regard to the defective lighting on the desks near to the opposite wall, this is often due to the presence of windows in the opposite wall with the idea of getting or giving borrowed light to or from the adjacent hall or corridor. He would also point out that the banking of the back rows of desks diminishes the light, and produces the difficulty that he is complaining about because the minimum angle of 25° of the top of the desk furthest from the window wall and the top of the window gets diminished with every successive row of desks that is banked, so that the desks in the back rows furthest from the windows are progressively worse lighted the more they are banked. The difficulty of not seeing the teacher properly in a long class-room, which Dr. Shrubsall refers to as being got over by banking the desks, is equally got over by

raising the teacher on a small platform, as is done in many Continental countries.

In answer to the speaker who raised the question of the lighting of the blackboard and the general position in which the blackboards are placed, he would point out that, according to the figures in a standard London County Council school-room, the light is often as low as '7 foot-candles, or even less, at a point two thirds of the distance from the window wall, and that to place the blackboard in the position indicated is to choose the worse lighted part of the room. He felt very strongly that the proper position of the blackboard is fixed to the facing wall, and occupying the two thirds or so nearest to the window wall. At the same time it is important that the window should be taken right up to the facing wall so as to efficiently light the blackboard. This, however, is seldom done. Sir Aston Webb, in the Christ's Hospital building at Horsham, put in a special window to obviate this defect.

With regard to the speaker who found that in testing vision in a room with very white walls the results were not so good as in a darker room, this seems to be obviously due to glare from the white walls.

Since reading his paper he found, on going closely into the dates of the publication of Dr. Kerr's and Mr. Bishop Harman's report and the Boston Report on School Lighting, that Dr. Kerr's and Mr. Bishop Harman's report precedes the Boston one apparently by about two months.

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